



## Environmental Issues and Pediatric Asthma

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## Learning Objectives

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- Attendees will learn more about the influence of environmental factors and air quality on health outcomes of children and adolescents with asthma.
- To introduce and provide practice in a method for taking an environmental exposure history in the office or clinic.

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## Learning Objectives cont'd.

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3. To provide an opportunity to acquire skills in exposure assessment, risk communication and management, and use of resources related to the effects of indoor and outdoor air contaminants on children and adolescents with asthma.

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## Epidemiology of Asthma

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- Increasing Morbidity and Mortality
- Ethnic Disparities
- Soaring Costs

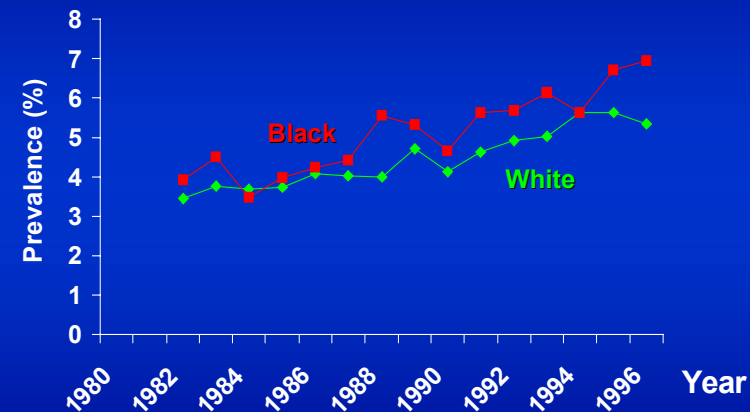
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## Epidemiology of Asthma

- Affects over 20 million people
- 5 million children
- Incidence and prevalence among children has increased significantly over past two decades. Prevalence 8-20%
- Asthma morbidity and mortality has increased disproportionately among low SES, minority children living in the inner city

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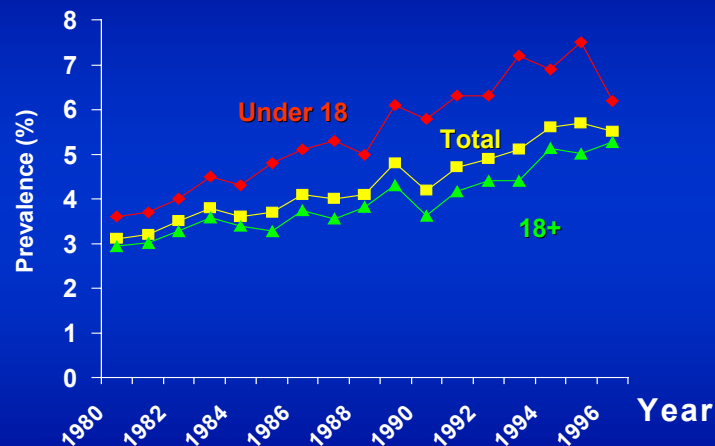
## Asthma Prevalence\* by Race United States: 1982–1996



Source: National Health Interview Survey  
\* 12-month prevalence



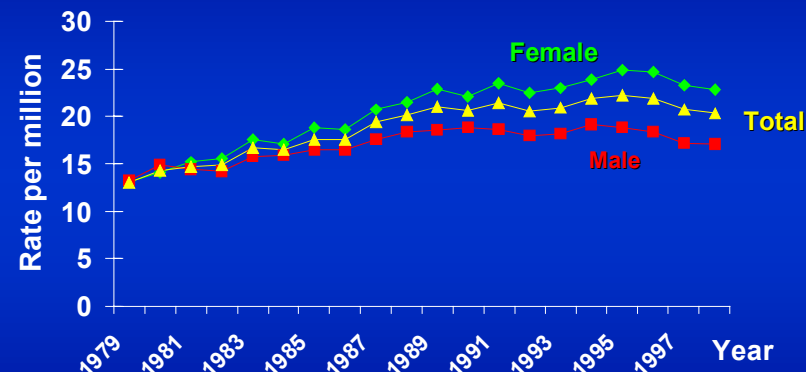
## Asthma Prevalence\* by Age United States: 1980–1996



Source: National Health Interview Survey  
\* 12-month prevalence



## Age-Adjusted\* Asthma Mortality Rates by Sex, United States: 1979–1998

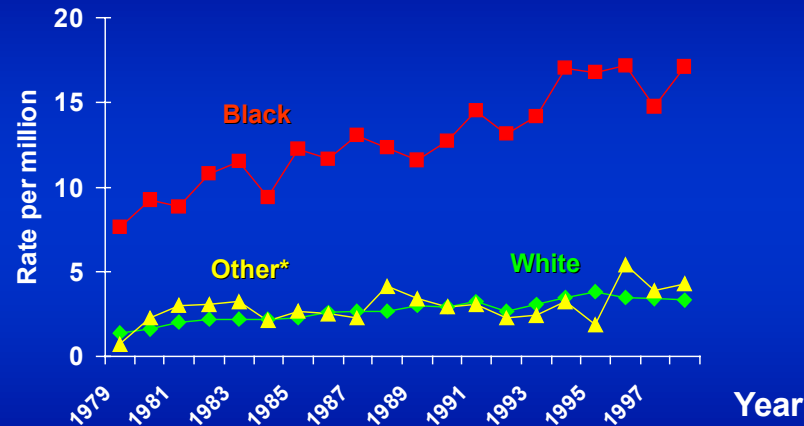


Source: Underlying Cause of Death dataset by the  
National Center for Health Statistics

\* Age-adjusted to 2000 U.S. population



## Asthma Mortality Rates by Race Ages 5-34, United States: 1979–1998



Source: Underlying Cause of Death dataset by the National Center for Health Statistics

\* Unreliable (< 20 deaths) 1979–1995



## Epidemiology

### Asthma's Impact on the U.S. Population

#### In 2001, an estimated

- 31.3 million people had been diagnosed with asthma during their lifetime
- 20.3 million people currently were diagnosed with asthma
- 12 million people experienced an asthma attack in the previous year

#### In 2000, asthma accounted for

- 10.4 million outpatient visits
- 1.8 million emergency department visits
- 465,000 hospitalizations
- 4,487 deaths

Source: CDC National Center for Health Statistics

<http://www.cdc.gov/nchs/products/pubs/pubd/hestats/asthma/asthma.htm>

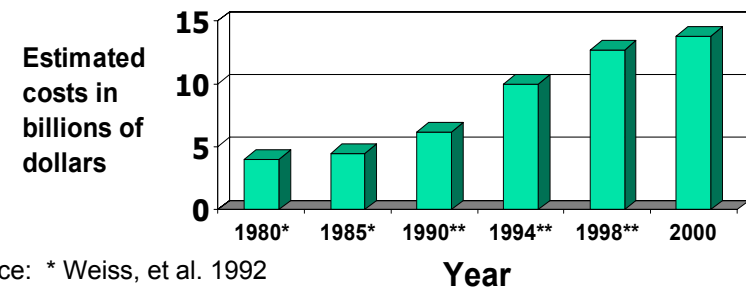
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## Soaring Costs

- Increasing prevalence and morbidity results in rising economic costs
- Increased investment is needed for tracking and surveillance

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## Costs of Asthma United States, 1980–1998 Projection for the Year 2000



Source: \* Weiss, et al. 1992

\*\* Weiss, et al. 2001

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## The Environment and Pediatric Asthma: Cost

**Table 2.** Estimated costs of pediatric asthma of environmental origin, United States, 1997.

Medical and indirect costs	U.S. dollars
Hospital care	
Inpatient	634 million
Emergency room	323 million
Outpatient	154 million
Physicians' services	
Inpatient	54 million
Outpatient	625 million
Medications	2.81 billion
Subtotal: medical costs	4.6 billion
Indirect Costs	
School days lost	1.78 billion
Premature deaths	193 million
Subtotal: indirect costs	2.0 billion
Total costs of pediatric asthma	6.6 billion
EAF	30% (range 10–35%)
Environmentally attributable costs of pediatric asthma	2.0 billion (range \$0.7–2.3 billion)

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## Risk Factors for Development of Asthma

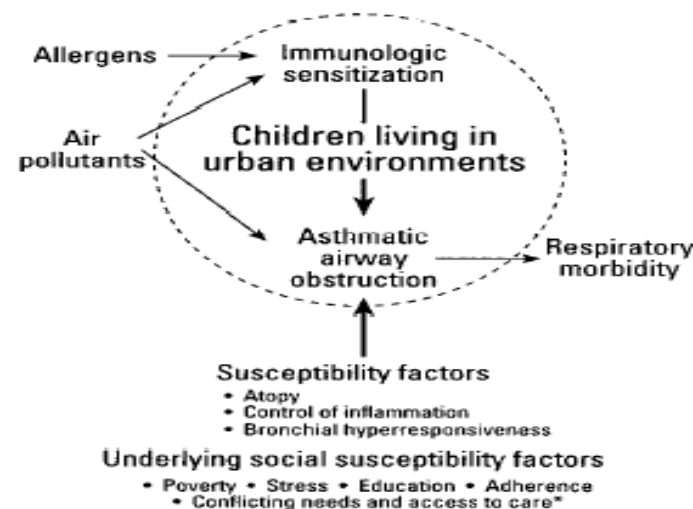
- Genetic characteristics
- Environmental exposures
- Contributing factors



## Role of Environmental Factors and Asthma

- Unresolved Question: To what extent are chemical pollutants in the environment contributing to the changing patterns of pediatric asthma?
- The burden of disease, disability and death in children that may be caused by pollutants has been poorly studied

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**Figure 1.** A model of the pathways in which environmental exposures and individual susceptibility interact to lead to symptomatic asthma.

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## Environmental Pollutants and Disease Among Children

- >80,000 new synthetic chemicals developed over past 50 years
- Many not tested for potential human toxicity, particularly among children
- This vulnerability/increased susceptibility results from children's disproportionately heavy exposures
- Injury to developing organ systems can cause life long disability

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## Why Children are More Vulnerable to Environmental Threats

- Sensitive Subgroups: Children are more susceptible because
  - they breathe more rapidly and inhale more pollutant per kg body weight than adults.
  - They spend more time outdoors being physically active, often in the afternoon when the ozone levels are highest, and
  - they are less aware of the irritative symptoms that would inhibit adults.

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## Environmental Allergens and Asthma

- Outdoor and Indoor Allergens are very common triggers
- 80% of children with asthma have allergies

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**Table 1.** Acute and chronic effects of ambient air pollution on children's respiratory health.

Acute effects	Chronic effects (putative)
Increased respiratory symptoms	Impaired functional lung growth
Increased respiratory illnesses	Earlier onset and increased rate of decline in lung function with aging
Asthma exacerbations	Increased lifetime risk for chronic respiratory diseases including chronic obstructive pulmonary disease, asthma, and lung cancer
Increased health care utilization	Altered lung structure including metaplasia of the respiratory epithelium in respiratory bronchioles, mononuclear peribronchiolar inflammation, localized deposition and alteration in collagen, and remodeling of the peribronchiolar airspace
Excess cardiorespiratory mortality	
Respiratory tract inflammation	
Increased airway reactivity	
Altered host defenses including oxidant defenses, mucociliary clearance, macrophage function, and immune response	

Adapted from Bascom et al. (7).

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## Outdoor Allergens

- The most widely abundant sources are pollen grains and fungal spores
- Noxious agents in the atmosphere: carbon monoxide, lead, sulfur dioxide, oxides of nitrogen, ozone, particulate matter (PM)
- Ozone and particulate matter have been associated with increased need for rescue medication, ER visits and hospitalizations for asthma.

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## Outdoor Air Quality

- **AQI:** The four most commonly measured air pollutants are: Particulate Matter, Sulphur Dioxide, Carbon Monoxide, and Ozone. It is reported as Good, Moderate, Unhealthy, and Very Unhealthy. In summer, a poor AQI is usually related to elevated ozone, and this in turn is usually associated with an increase in fine particles in the air. An AQI of 100 or more is regarded as very unhealthy.

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## Air Pollution

- Pollutants:
  - Ozone: Ground level ozone, as opposed to stratospheric ozone (the ozone layer), is a colorless gas that is formed when its precursors, oxides of nitrogen and hydrocarbons, interact in the atmosphere in the presence of high temperatures and sunlight (photochemical reactions).

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## Air Pollution(cont)

- **Ozone (cont):**
  - Nitrogen oxide precursors (Nox): emitted from the combustion of fossil fuels, mainly from motor vehicle exhausts.
  - Hydrocarbon precursors, volatile organic compounds (VOCs): produced by motor vehicle exhausts, industrial processes and by evaporation of gasoline from gas pumps, of surface coatings such as oil-based paints, and of solvents such as cleaners and barbeque starter fluid.

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## Air Pollutants (cont)

### ■ Particulates

- Fine particles: solid or liquid, which because of their small size, <10 microns (PM 10) or < 2.5 microns (PM 2.5), remain suspended in air, and when inhaled, penetrate deep into the airways, to the alveoli and bronchioles.
- Composition: vary in chemical composition, but a large fraction can be acidic, mostly sulphates from burning of fossil fuels.

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## Air Pollutants (cont)

### ■ Particulates (continued)

- Acidic fraction: mostly made up of the finer PM 2.5 particles, called acid aerosols.
  - Likely to be the most harmful to the bronchioles and the alveoli.
- Particulates are produced by motor vehicle exhaust, especially diesel, coal burning power plants and wood smoke.

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## Outdoor Air Pollutants

### ■ What are the pollutants of concern in the summer?

**Smog:** Although air quality has generally improved over the past 15 years, there is concern about the health effects of smog. Smog is the term given to the chemical "soup" that is the product of photochemical reactions. Because of this, highest levels are recorded on hot sunny days with clear blue skies and a light wind from the southwest; those beautiful summer days.

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## Outdoor Air Pollutants (cont)

Smog: consists essentially of elevated concentrations of ground-level ozone and fine airborne particles (particulates). Problem areas include southern Ontario, Chicago, Los Angeles. **This is a significant public health problem.**

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## Air Pollutants (cont)

- How do the components of smog, I.e., Ozone and Particulates, affect health?
  - A **Smog Advisory** is issued when average regional levels of ozone are forecast to reach 800ppb with local peaks anticipated at 120ppb or greater. These levels of ozone are associated with health effects, and can exacerbate asthma, chronic respiratory disease, and cardiac conditions.

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## Asthma and Indoor Air Pollution

- Indoor air pollutants can be categorized as:
  - Aero-allergens
  - Indoor particulate matter
  - Indoor gases
- Sensitization to one or more of these allergens contributes to asthma severity. In children, compared to adults, allergens play a greater role in asthma.

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## Indoor Allergens

- **A. Indoor Allergens**
  - House dust mites. Found in furnishings (eg. Mattresses, sofas, carpeting)
  - Pets, furry or feathered
  - Mice, rodent infestation, should be considered in the inner city, as well as:
  - cockroaches

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## Indoor Allergens (cont)

- **B. Gases**
  - Formaldehyde and VOCs are respiratory irritants produced by many substances in modern homes, including insulation, fabrics, carpets, solvents, floor adhesives, particle board, wood stain, paint, cleaning products, polishers and room deodorants and fresheners.
- **C. Particulates**
  - Environmental Tobacco Smoke (ETS)
  - Fireplace or wood stove.
  - Fiberglass from clothing

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## Indoor Allergens

- **D.Fungi/Molds.** Their concentrations are a function of humidity/moisture, and high levels are found in damp basements, and in damp areas around garbage containers, food storage areas, wall paper, shower curtains and window moldings. Most common are Alternaria, Cladosporium and Penicillium molds. Besides allergic effects, some toxigenic molds (eg Stachybotris Chartarum/atra) produce mycotoxins and glucans, which cause toxic effects.

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## Risk Factors for Development of Asthma: Environmental

### *Clearing the Air: Asthma and Indoor Air Exposures*

<http://www.iom.edu> (Publications)

Institute of Medicine, 2000

Committee on the Assessment of Asthma and Indoor Air

### Review of current evidence regarding indoor air exposures and asthma



## Clearing the Air

### Categories for Associations of Various Elements

- Sufficient evidence of a causal relationship
- Sufficient evidence of an association
- Limited or suggested evidence of an association
- Inadequate or insufficient evidence to determine whether an association exists
- Limited or suggestive evidence of no association



## Clearing the Air

### Indoor Air Exposures and Asthma Exacerbation

#### Biological Agents

- Sufficient evidence of a causal relationship
  - Cat
  - Cockroach
  - House dust mite
- Sufficient evidence of an association
  - Dog
  - Fungi/Molds
  - Rhinovirus
- Limited or Suggestive Evidence of an Association
  - Domestic birds
  - Chlamydia and Mycoplasma pneumoniae
  - RSV

#### Chemical Agents

- Sufficient evidence of a causal relationship
  - Environmental tobacco smoke (in preschool-aged children)
- Sufficient evidence of an association
  - NO<sub>2</sub>, NO<sub>x</sub> (high levels)
- Limited or suggestive evidence of an association
  - Environmental tobacco smoke (school-aged, older children and adults)
  - Formaldehyde
  - Fragrances

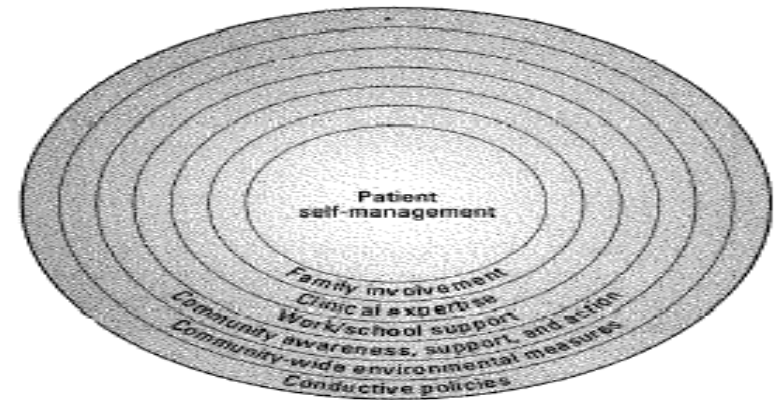


## Management Pediatric Asthma and Environmental Triggers

- Requires Knowledge of
  - Growth and Developmental Issues pertaining to children and adolescents
  - Epidemiology and Pathophysiology of Asthma
- Use of Allergen Avoidance Measures
- Ecological Approach

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## Management/Avoidance of Exposures



**Figure 1.** Concentric circles of influence in asthma control.

## Environmental History: CH2OP

- **C**ommunity: Air quality in community
- **H**ome: age and type of construction, ventilation, smokers, pets; etc.
- **H**obbies: outdoor sports; painting
- **O**ccupation: Parents and Adolescents
- **P**ersonal: Medical and social history

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## Outdoor Air Quality

- What is the status of the outdoor air in your community? How would you find this out?
  - **For Outdoor Air Pollutants:**
    - **In Chicago:** The EPA (Environmental Protection Agency) measures and reports the status of air quality. This can be accessed at 708-865-6320. The Air Quality Index (AQI) synthesizes the four most commonly measured air pollutants.

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## Outdoor Exposure Prevention

### ■ Primary Prevention

- Reduce car use by using public transportation and car pooling whenever possible.
- Walk or ride your bicycle (wearing a helmet) when smog levels are not high.
- Keep your car well tuned, and check the emission control system.

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## Outdoor Exposure Prevention (cont)

### ■ Primary Prevention (cont)

- Avoid idling (cars and school buses) for long periods. Turn off engine.
- Driving at moderate speeds uses less fuel. Buy a fuel efficient vehicle.
- Use alternatives to other gasoline-powered vehicles and machines, such as motorbikes, motorboats, and gas lawn mowers
- Solvents in household cleaners and in surface coatings like oil-based paints are a major source of VOCs. Choose alternatives (eg water-based paints).

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## Outdoor Exposure Prevention (cont)

### ■ Primary Prevention (cont)

- Advocacy and political action: regarding sulphur content of gasoline, motor vehicle emission standards, urban planning and public transportation issues.

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## Counseling and Allergen Avoidance

- How would you counsel the patient and family about how to deal with outdoor trigger factors?
  - Be aware of smog advisories in their area when they are issued via the media.
  - Attempt to reduce exposure to smog. They should understand that outdoor activity during smog advisories increases exposure, so that the child should be careful with outdoor activities. He might need to stay indoors if asthma worsens.

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## Counseling for Outdoor Exposures (cont)

- Increase monitoring of his Peak Flow during Smog Advisories, and follow patient's action plan by increasing his inhaled steroids and Ventolin if Peak Flow drops.
- It is also appropriate to give them information about the larger picture of how smog is formed, and what the individual can do personally and in an advocacy role to reduce the problem.

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## Indoor Exposures: Allergen/Irritant Avoidance Measures & Counseling

- How would you counsel parents to avoid the effects of indoor factors?
  - Do you have handouts re: avoidance measures?
  - Handouts are available from: The American Academy of Asthma, Allergy and Immunology (AAAAI), American Academy of Pediatrics (AAP), The American Lung Association, EPA, NIEHS.

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## Indoor Allergen/Irritant Avoidance Measures (cont)

- Reducing the mite population: important but difficult
  - Bedding. The single most effective strategy is to cover mattresses, comforters, and pillows with dust mite encasements. Replace feathered pillows and bedding with synthetic products. Bedding should be washed at least weekly in hot water over 55C.

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## Allergen/Irritant Avoidance Measures (cont)

- **Indoor Allergen Avoidance (cont)**
  - Flooring. Remove carpets and upholstered furnishings. Chemical treatments are less effective. Vacuum once a week.
  - Humidity. Reduce humidity levels below 50%, and keep temperature levels below 25C.
  - Remove pets from the home.

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## Environmental Control (cont)

- Cock roaches. Minimize exposure to pesticides. Proper food clean-up and storage. Fix leaks and cracks in floors, walls and other areas they're frequently found.
- Mold. Reduce humidity. Clean contaminated areas with chlorine bleach. Repair and remove water-damaged materials. Proper ventilation is important.

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### Appendix 1. Essential teaching/action points of the basic and intensive versions of the modules.

#### Safe sleeping zone

- Provide overview of intervention in context of relationship of asthma to allergens and ETS
- Describe how child's skin tests and exposures from parental report/evaluators observations will guide intervention activities
- Purpose of module: Make child's bedroom as allergen free and smoke free as possible
  - Apply mattress and pillow covers
  - Install air vent filtration covers where applicable; check for mold
  - Demonstrate vacuuming/damp mopping/damp dusting all surfaces
  - Encourage caretaker to adopt allergen reduction activities
    - Wash bedding in hot water at least every 2 weeks
    - Remove or vacuum carpets, damp dust every week
    - Freeze/wash stuffed toys

#### Cockroach module

- Develop activity goals with caretaker to continue safe sleeping zone activities
- Provide caretaker education about cockroach behavior and integrated pest management
- Demonstrate cleaning strategies such as shelf cleaning, sealing of nonrefrigerated food, countertop cleaning, mopping of kitchen, garbage and trash removal
- Remove visible cockroach stain and droppings
- Provide professional extermination services involving sealing of cracks and crevices, application of hydramethylnon gel baits and bait stations, hydroprene growth retardant

#### Rodent module

- Provide caretaker education about rodent behavior
- Identify entry points with caretaker and seal them with copper mesh
- Review and demonstrate cleaning and food storage methods as for cockroach module

- Give family a HEPA air purifier for child's room and instructions in its use
- ETS module
  - Provide caretaker education about importance of avoiding ETS at home and in public places
  - Give all families "No Smoking/Lungs at Work" signs for home and child's bedroom
- Develop strategies with caretaker to eliminate or reduce child's exposure at home, primarily to keep ETS out of the child's bedroom
- Provide list of local smoking cessation programs if caretaker assessed as ready to change

#### Furry pet module

- Give family a HEPA air purifier for child's room and instructions in its use
- Provide caretaker education on pet allergens and their relationship to asthma
- Provide caretaker education on avoidance of pets outside home
- If pet in home presently or within past 6 months, give HEPA air purifier and instructions in use
- If pet in home presently, discuss strategies for pet removal or pet avoidance. Pet removal is the goal; secondary goal is banning pet from child's room, operating HEPA air purifier daily, encouraging child to wash hands after touching pet

#### Mold module

- Provide caretaker education on sources of mold/moisture in the home (e.g., leaking windows, damp mops, plumbing leaks, humidity in child's bedroom, number of houseplants, moldy smells, visible mold on walls/woodwork)
- Wash moldy surfaces with 10% bleach solution and instruct caretaker in preparation and use of solution
- Discuss importance and methods of providing ventilation and not using home humidifiers
- Give family a HEPA air purifier for child's room and instructions in its use

\*Denotes component added to basic module to comprise intensive version.

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## Other Management Issues

- Allergy testing?
- How should patients be managed while family institutes environmental control measures?

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## Other Management Issues

### ■ Allergy Testing

Allergy testing, by skin prick, would likely be very useful in guiding the avoidance measures. For example, it is difficult for families to get rid of a cat or dog, and this should only be advised with evidence of cat or dog allergy.

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## Other Management Issues (cont)

- Management while waiting for institution of environmental control measures
  - Inhaled corticosteroids can be increased in the short term, or a long-acting bronchodilator added, until hopefully environmental controls have helped reduce her reactivity.

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## Summary, Conclusion

- Exposure to environmental irritants and allergens is associated with adverse outcomes among children with asthma.
- Reducing exposure to these environmental hazards should be a clear priority in developing effective management plans for pediatric patients with asthma.

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## Websites

- Children's Health and the Environment
  - PEHSUs: [www.atsdr.cdc.gov](http://www.atsdr.cdc.gov); [www.aoec.org](http://www.aoec.org)
  - [www.epa.gov](http://www.epa.gov)
  - [www.cdc.gov/nceh](http://www.cdc.gov/nceh): National Center for Environmental Health
  - <http://ehis.niehis.nih.gov>: National Institute of Environmental Health Sciences
  - [www.checnet.org](http://www.checnet.org): Children's Health Environmental Coalition Network

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## Websites

- Children with Asthma
  - [www.aap.org](http://www.aap.org): American Academy of Pediatrics
  - [www.aaaai.org](http://www.aaaai.org): The American Academy of Asthma, Allergy and Immunology
  - [www.nhlbi.nih.gov](http://www.nhlbi.nih.gov): NIH
  - [www.niaid.nih.gov](http://www.niaid.nih.gov): NIH
  - [www.lungusa.org](http://www.lungusa.org): American Lung Assoc.

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